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14. ABSTRACT

Polarizing optical fibers are an important component for building compact fiber lasers with linearly polarized laser output. Conventional single-mode optical fibers with birefringence can only preserve the polarization when the incident beam is launched properly. Recent reports demonstrate that the birefringence in photonic bandgap fibers (PBFs) can provide single-polarization operation by shifting the transmission band of the light with orthogonal polarizations, thus to create the staggered region in which only one polarization light can propagate [add ref]. Here,

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Polarizing optical fibers are an important component for building compact fiber lasers with linearly polarized laser output. Conventional single-mode optical fibers with birefringence can only preserve the polarization when the incident beam is launched properly. Recent reports demonstrate that the birefringence in photonic bandgap fibers (PBFs) can provide single-polarization operation by shifting the transmission band of the light with orthogonal polarizations, thus to create the staggered region in which only one polarization light can propagate [add ref]. Here, we demonstrate a 50µm core Yb-doped polarizing photonic bandgap fiber (PBF) for single-polarization operation of high power linearly polarized fiber lasers. The single-polarization operates through the entire transmission band from 1040nm to 1180nm with polarization extinction ratio (PER) of >6dB/m. 5 meter long fiber was also tested in a laser configuration and a linearly polarized laser output at 1026nm was achieved with PER value of 27dB without using any polarizers.

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Polarizing 50µm core Yb-doped photonic bandgap fiber

Fanting Kong*[a], Guancheng Gu[a], Thomas Hawkins[a], Joshua Parsons[a], Maxwell Jones[a], Christopher Dunn[a], Monica T. Kalichevsky-Dong[a], Benjamin Pulford[b], Iyad Dajani[b] and Liang Dong[a]
[a]ECE/COMSET, Clemson University, 91 Technology Drive, Anderson, SC, 29625, USA
[b]Kirtland Air Force Base, Albuquerque, NM 87117, USA

Polarizing optical fibers are an important component for building compact fiber lasers with linearly polarized laser output. Conventional single-mode optical fibers with birefringence can only preserve the polarization when the incident beam is launched properly. Recent reports demonstrate that the birefringence in photonic bandgap fibers (PBFs) can provide single-polarization operation by shifting the transmission band of the light with orthogonal polarizations, thus to create the staggered region in which only one polarization light can propagate [add ref]. Here, we demonstrate a 50µm core Yb-doped ~~birefringent~~ polarizing photonic bandgap fiber (PBF) ~~fiber with~~for single-polarization operation ~~for~~ of high power linearly polarized fiber laser ~~applications~~. The single-polarization operates through the entire transmission band from 1040nm to 1180nm with polarization extinction ratio (PER) of >6dB/m. 5 meter long fiber was also tested in a laser configuration and a linearly polarized laser output at 1026nm was achieved with PER value of 27dB without using any polarizers.

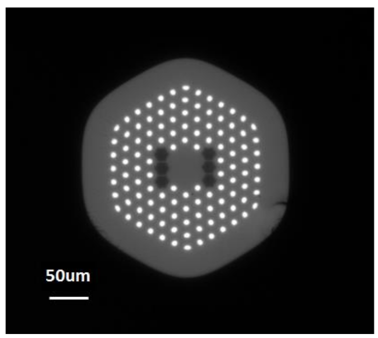

Fig. 1. Cross-section of passive birefringent PBF.

Fig.1 shows the cross-section image of a passive birefringent PBF fiber. The out-cladding (OD) is 255µm flat-to-flat and 270µm corner-to-corner. The periodical lattice structure in the cladding is made of germanium doped high-index rods which provide photonic bandgap effect and guide light in the core. The missed seven high-index rods at the center form the core of the fiber which is 40µm and 62µm along the slow and fast axis respectively. The birefringence of 3.2×10^{-4} in this fiber is obtained by incorporating six low-index boron-doped rods on either side of the core, which also provide light confinement by total internal reflection in addition to the bandgap guiding in other directions.

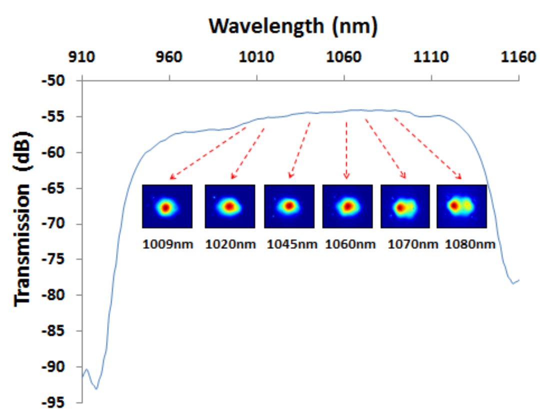

Fig.2. Transmission band in passive birefringent PBF.

The transmission band in this passive fiber was tested by launching un-polarized white light into 3m long fiber bended at 55cm diameter and measuring the transmitted light in the core, which is shown in Fig.2. The transmission band was measured from 990nm to 1110nm within the 3rd order photonic bandgap of the PBF fiber, with robust single-mode operation near the high-frequency bandgap edge and multimode operation near the low-frequency bandgap edge, as illustrated by inserted photos in Fig. 2. These inserted mode pattern images were taken by using a tunable laser scanning within the transmission band.

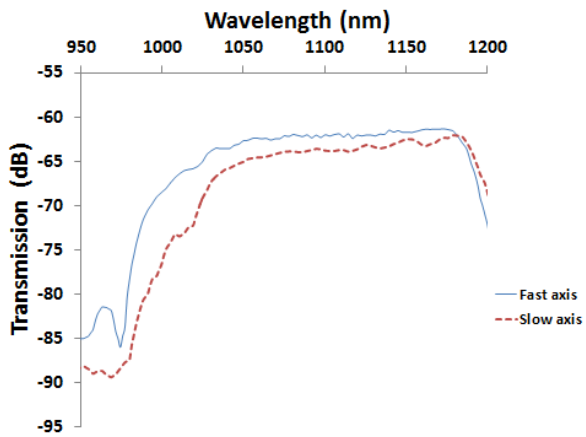

Fig. 3. Transmission band along fast and slow axis in 30cm Yb-doped birefringent PBF.

The Yb-doped active birefingent PBF fiber was similar to the passive fiber and was rescaled from previous tested passive PBF in order to move 1064nm wavelength to the high-frequency edge of the bandgap ~~with~~ where robust single-mode operation can be achieved. Polarized white light was launched into 30cm long straight active fiber and the transmission was measured for light polarized along fast and slow axis individually, shown in Fig. 3. The dashed line represents the transmission for light polarized along the ~~slow~~ fast axis, which is about >1.8dB lower than the light polarized along the slow~~fast~~ axis within the entire transmission band from 1040nm to 1170nm. This higher transmission loss for the ~~slow~~fast-axis polarized~~ation~~ light is due to the fact that light at the fast axis has lower effective mode index due to the birefringence from the stress rods and is therefore weakly guided. The fast-axis mode is closer to the modes in the photonic cladding and ~~guided in the core~~ is easily coupled into cladding ~~when the effective refractive index of core-guided mode is reduced close to the bottom of photonic bandgap~~. ~~This refractive index reduction is caused by the birefringence in the fiber along slow axis.~~ Thise differential polarization transmission loss results in ~~the~~ single polarization operation in this fiber with a PER value of >6dB/m. This is likely much higher in coiled fibers.

5m long active PBF fiber was also tested in a laser configuration when bended at 55cm coil diameter. A lasing efficiency of 56% relative to the absorbed pump power was achieved at 1026nm lasing wavelength. The laser output is linearly polarized with a PER value of 27dB.